Persuasive technology and digital design for behaviour change

Dan Lockton[1,2]

[1]Brunel Design, Brunel University, Uxbridge, Middlesex, UB8 3PH, UK
[2]WMG, University of Warwick, Coventry, Warwickshire, CV4 7AL, UK

dan@danlockton.co.uk

Please cite as: Lockton, D (2012), 'Persuasive technology and digital design for behaviour change', working paper, available at http://danlockton.co.uk

Abstract

The convergence of the 'digital' and 'real' worlds has been rapid and transformative of everyday life, as well as design practice—to the extent that talking about 'digital design' and 'the digital context' seems, to some extent, anachronistic and redundant. Nevertheless, the arrival of digital technology, the Internet and social media has, from a design perspective, created a new field of affordances, constraints, information flows and possibilities. This paper reviews some of the ways in which digital architecture influences behaviour, and what the implications could be for designers seeking to influence behaviour for social and environmental benefit. Topics covered include Persuasive Technology, gamification, Lessig's 'Code is Law' perspective, digital rights management and Zittrain's concept of generativity.

1 Introduction

The convergence of the 'digital' and 'real' worlds has been rapid and transformative of everyday life, as well as design practice—to the extent that talking about 'digital design' and 'the digital context' seems, to some extent, anachronistic and redundant. Nevertheless, the arrival of digital technology, the Internet and social media has, from a design perspective, created a new field of affordances, constraints, information flows and possibilities, many of which have influenced our behaviour significantly and which were not present in the same way previously.

This paper reviews some of the ways in which digital architecture influences behaviour, and what the implications could be for designers seeking to influence behaviour for social and environmental benefit.

2 How digital architecture influences behaviour

Digital architecture, the structure of software, and of systems such as the Internet, is associated with influencing human behaviour in a number of ways. Aside from the societal effects which mass communication, distribution of information, and social networking have facilitated, most work on this subject focuses on how the affordances and constraints (see Lockton 2012a) designed into the Internet, computer systems and software applications—or which have the potential to be applied to these systems—could be used to influence user behaviour for commercial or political reasons.

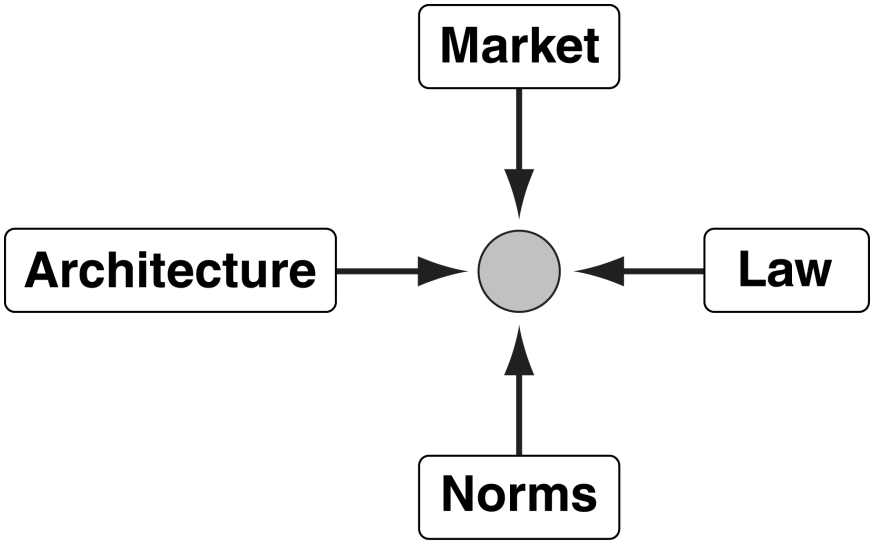

Figure 1: The four forces regulating the behaviour of this "pathetic dot" (based on Lessig, 1999, p.88)

2.1 Code is law

Lawrence Lessig has been at the forefront of much debate in this area, particularly on issues of intellectual property, digital rights, and how the Internet is constructed and regulated. In *Code and Other Laws of Cyberspace* (Lessig, 1999), the concept of 'code is law' is outlined: the principle that while the law is a substantial regulator of human behaviour offline, online it is 'code' (i.e. software, as well as the hardware architecture of the Internet) that predominantly structures what people can and cannot do. Lessig memorably (1999, p.53) contrasts "East Coast Code" (i.e. laws made in Washington, DC) with "West Coast Code" (software written largely in Silicon Valley or Redmond). As Zittrain (2008, p.104) put it, "the software we use shapes and channels our online behaviour as surely as—or even more surely and subtly than—law itself." The author's previous research (Lockton, 2005) and blog focusing on 'architectures of control' in design took its name from Lessig's use of the term (1999, p.30).

Lessig offers a simple model (Figure 1) where four forces determine the behaviour of a "pathetic dot" (representing "a creature (you or me) subject to the different constraints that might regulate it" (1999, p.86).

The model is extremely simple, and concerns primarily 'context' factors affecting—specifically, 'regulating'—behaviour, rather than focusing on cognitive factors. Using smoking as an example, Lessig (1999, p.87) suggests that people's behaviour is regulated by the sum of the four forces acting in any situation: *law* may affect whether or not someone smokes (e.g. if someone is underage, the law prevents him or her buying cigarettes); *norms* affect whether or not is socially acceptable to smoke in different circumstances, such as in someone else's car or at a picnic; *market* forces affect the price of cigarettes and their availability; and what Lessig calls the *architecture*—the structure or technology or design or inherent features—of the cigarettes, such as the the existence of filtered and unfiltered, strongly odoured and smokeless types, also affects whether, where and when they are smoked.

Lessig goes on to apply the model to what regulates behaviour in cyberspace, arguing that online, code is effectively architecture, and whoever controls it controls behaviour. It is not difficult to see *design* (at least in terms of affordances and constraints) as a synonym for architecture in the pathetic dot model. The model is, however, limited in its scope.

2.2 Parallels between digital and physical architecture

The parallels between 'real-world' physical architecture and digital architecture (often metaphorically) are prominent in discussions of 'cyberspace'—terminology such as 'chat room', 'surfing', 'digital locker' (more recently), 'cloud', and even 'website' itself all reference physical contexts, although offering very different affordances to users. As Vaidhyanathan (2005, p. xi) notes, "[t]he metaphors we use to discuss controls in cyberspace always appear clumsily lifted from our more familiar transactions: locks, gates, firewalls, crowbars, vandals and shoplifters." Katyal (2003, p.101), specifically discussing digital architecture and criminal behaviour, suggests that "despite apparent metaphorical synergy, architects in realspace generally have not talked to those in cyberspace, and vice versa." As with physical architecture, much work on how digital architecture can be used to influence behaviour has centred on crime. Katyal argues that "the architectural methods used to solve crime problems offline can serve as a template to solve them online. This will become increasingly obvious as the divide between realspace and cyberspace erodes. With wireless networking, omnipresent cameras, and ubiquitous access to data, these two realms are heading toward merger. Architectural concepts offer a vantage point from which to view this coming collision" (Katyal, 2003, p. 102).

Katyal's observations do not just apply to crime; from a 2011 standpoint, it is clear that the 'Internet of Things' (Bleecker, 2006), pervasive computing and *ubicomp* (ubiquitous computing), of the kind explored by McCullough (2004), Sterling (2005) and Greenfield (2006), comprise an accelerating convergence of physical and digital architecture in a way which does not simply reproduce physical structures metaphorically online, but in that conjunction offers some completely new affordances, to users, to governments[1] and to corporate interests, many of which involve influencing behaviour.

2.3 Generativity

Zittrain (2008) argues that the end-to-end structure of the Internet (Saltzer et al, 1984), in which features "not universally useful" to all users were not implemented via the network itself, but left up to the endpoints (i.e. users' computers) to devise and handle, prevented the Internet "becoming tilted towards certain uses" (Zittrain, 2008, p. 31). This property—architecture designed to provide a generic information routing system, treating all data with the same priority no matter from where and to whom they are being sent—is fundamental to Zittrain's concept of the Internet as a *generative* system, "built on the notion that [it is] never fully complete, that [it has] many uses yet to be conceived of, and that the public can be trusted to invent and share good uses" (Zittrain, 2008, p.43). Drawing parallels with the concept of affordances, Zittrain (2008, p. 71-73) suggests that generative systems have the qualities of *leverage* (making a task easier); *adaptability*; *ease of mastery*; *accessibility*; and *transferability* (of changes or innovations).

In this sense, within the bounds set by Lessig's West Coast Code, the architecture of the Internet does not itself seek to influence behaviour, but it does enable services to be built on top of it (often by 'amateurs') which in turn enable lots of new behaviours, as well as changing the ease with which certain behaviours can be influenced. For example, Tim Berners-Lee's decision to allow non-reciprocal (unidirectional) hyperlinks to be made on the World Wide Web meant that anyone could create a link to others' web pages without asking permission first (Forder, 2000)—making it much faster and easier to create web pages, as well as potentially lowering the hurdles to creating critical content—which differed from some earlier planned hypertext systems such as Ted Nelson's Xanadu (Wolf, 1995; Tredinnick, 2009). In another example, Spinellis and Louridas (2008, p.70) suggest that Wikipedia's use of 'red links' as "references to nonexistent articles trigger the eventual creation of a corresponding article," and

[1] Losh (2009) details governmental attempts to make use of digital technology to influence and engage with the public, elaborating a new field of 'digital rhetoric'.

are partly responsible for the free, community-generated encyclopaedia's phenomenal growth. Indeed, Wikipedia co-founder Jimmy Wales argues that much of its success has been due to relative *laissez-faire* policies towards moderating contributors' behaviour, suggesting that "[w]hen you try to prevent people from doing bad things, the very obvious side effect is that you prevent them from doing good things" (Brand, 2009, p.162).

Emergent use of services such as Twitter to provide real-time updates on breaking news from members of the public (e.g. in Egypt and Iran: Grossman, 2009; BBC, 2011) brings others into contact with the thoughts and concerns of millions of people worldwide of whom they otherwise would not be aware. Shapiro (1999, p.109) argued that with the power to control and filter more and more of the information they come across ("selective avoidance"), or with algorithms doing it for them (Pariser (2011) calls this the "filter bubble"), people may become focused on very narrow interests, avoiding disconfirming points of view, and consciously preventing themselves experiencing cognitive dissonance (see Lockton, 2012b for relevance to design for behaviour change).

While this may be true in many cases, the generative nature of services such as Twitter suggests that the underlying architecture permits and enables new behaviours to emerge on a scale hitherto unprecedented.

3 Controlling user behaviour through digital architecture

Despite the power of generativity, the emergence of what Zittrain (2008) calls 'tethered appliances'—"[networked] devices hardwired for a particular purpose" (p. 12) such as the iPhone, Nintendo Wii, Kindle eBook reader and TiVo digital video recorder—"will affect how readily behaviour on the Internet can be regulated, which in turn will determine the extent that regulators and commercial incumbents can constrain amateur innovation, which has been responsible for much of what we now consider precious about the Internet" (p. 9). Tethering here includes the ability for the manufacturers or retailers of appliances to modify their functions remotely via software and firmware updates, even years after purchase by the customer, thus altering the behaviours that are possible from the user's point of view.

This affordance of 'specific injunction' blurs the line between product and service in a manner which could benefit the user (in terms of offering more or improved features) but could also be used to restrict and control users' behaviour in a way which was simply not possible with non-networked physical products in the past—remotely disabling functions, censoring content or even deleting every copy of a file across a network. For example, Amazon's (unintentionally ironic) 'unpublishing' of Orwell's *1984* and *Animal Farm* from Kindle devices (Fleishman, 2009) was possible because despite having paid for the eBook, the users only had a 'licence' to read the content rather than owning the copy in the same way as a physical book, and the architecture afforded withdrawing the content from users at Amazon's behest. Gillett et al (2001) contended that any new, restrictive Internet appliance would be at an immediate disadvantage compared with general purpose PCs, even if simply because users would be dissatisfied by these devices' lack of forwards compatibility and adaptability, but it is unclear whether this will hold true in the era of the App Store.

3.1 Digital rights management, price discrimination and network neutrality

Digital rights management (DRM), of which the Amazon unpublishing is an example, refers to measures designed to control and restrict user behaviour with files (music, videos, software, eBooks), and devices on the pretext of enforcing rights (whether or not these are legally enforceable in the jurisdiction concerned). This may include copy protection, locking users to particular devices or formats, only enabling functions for a certain time (a form of built-in obsolescence), driving users to purchase extra equipment

or subscriptions, or other ends which Doctorow (2004) points out are essentially about enforcing business models through controlling users' behaviour—removing affordances and adding constraints. The author's previous work (Lockton, 2005) includes a more detailed exploration of some of the design techniques and implications involved.

Gillespie (2007, p. 248) argues that "[i]n the end, DRM is not a way to regulate duplication and distribution; it is a way to guide and track purchase, access and use in ways that monetize what users do, and only then to constrain redistribution and reuse through commercial and technical boundaries". Following Gillespie's argument, one practice which digital architecture has made easier is price discrimination—"charging different customers different prices for the same good" (McAfee, 2002, p. 260). This has long existed as a business practice, but automated customer profiling (e.g. using cookies) has allowed mass 'pricing customisation' by online retailers based on customers' purchasing history or even the search terms used to arrive at a site (Ramasastry, 2005).[2] Hill (2007) introduces the term *antifeatures* to describe the result of business models which depend on intentionally 'crippling' one version of a product (also known as a *damaged good*) in order to enable more to be charged for the uncrippled version, or to enable a company to offer a 'more comprehensive' range. For example, according to McAfee (2007), Sharp sold two models of DVD player, the DVE611 and DV740U, priced differently because of the 'extra' ability of the DVE611 to play PAL DVDs—though, in fact, both models had this feature and the cheaper DV740U's remote control simply had a different plastic fascia covering over the button which enabled the PAL mode. (Once this information became known online, a number of DV740U owners cut the plastic away to reveal the button and effectively 'upgrade' their DVD players.)

Odlyzko (2004) notes that telecommunications companies are able to achieve revenues of $3,000 per megabyte of data sent through SMS, yet the same data sent through cable TV would yield only $0.00012 per megabyte. The Internet itself—where, effectively, all data are priced the same, thanks to the end-to-end architecture—generally lacks an ability to carry out price discrimination at this level, hence the "push in the telecommunications industry for new network architectures that would provide service providers greater control of what customers do, and would deviate from the 'stupid network' model of the Internet". This is what underlies the debate on network neutrality and traffic shaping (e.g. Kanuparthy and Dovrolis, 2011): many telecommunications firms would like to be able to overturn the current architecture and prioritise the transmission of certain data, either to enforce existing business models (e.g. charging more for VoIP calls, to make them less competitive than mobile calls) or to establish new ones, influencing consumer behaviour accordingly, e.g. Negroponte's pondering (1995, p. 79) whether, "[i]f AT&T and Disney merge, will the new company make it less expensive for children to access Mickey Mouse than Bugs Bunny?"

3.2 Surveillance and security

Zittrain notes that tethered devices afford surveillance, in the sense that they may report back to the manufacturer or retailer on users' behaviour with the device. Automated, pervasive surveillance in this manner is common to much digital architecture, from website analytics to tracking cookies, carried out by search engines, advertisers, internet service providers and governments. The torrent of information generated can be mined for behavioural patterns and individuals and groups profiled; Conti (2009, p.310), displays some concerns: "Just as a dog that has tasted human blood can no longer be trusted, I'm concerned that when online companies, and governments, feel the surge of power that online stockpiles of information provide, there will be no turning back."

Until recently, this level of surveillance has been more difficult to accomplish in the real world,

[2] In an explicitly behavioural vein, *persuasion profiling* (Kaptein and Eckles, 2010) involves the development of websites which adapt the influence strategies used based on profiling users' responses to different persuasion techniques.

although the density of CCTV in cities such as London is arguably creating a degree of pervasive surveillance, even if the systems are not (yet) linked up efficiently. Freeman and Freeman (2008, p.5) note that "[t]here are reckoned to be more than five million CCTV cameras in Britain—more than 20 per cent of the world's total—but we don't seem to feel any more secure."

Surveillance can act as a deterrent as well as allowing investigation of behaviour after the fact; in terms of influencing behaviour, the belief or subconscious feeling that one is being watched can have an effect on behaviour even when the 'eyes' are no more than a poster (Bateson et al, 2006). Greenfield (2011) makes the point that many domed CCTV cameras are, aesthetically, similar to 'eyes', whether this is done deliberately or not. The advances afforded by digital technology do also permit sousveillance on a larger scale, with the public able to monitor the behaviour of (for example) the police in a way which was previously more difficult. Brin (1998) argues for 'reciprocal transparency', that the public must come to use the same tools of surveillance (or sousveillance) that governments and corporations use on them, to enforce accountability. "Through reciprocal transparency, we might enforce fairness simply by using one of the oldest and most famous parables, "Judge not, lest ye be judged". Fairness would be compelled not by exhortation and regimentation but by demanding equal application of the Golden Rule" (Brin, 1998, p. 82). Some initiatives from the UK's MySociety such as TheyWorkForYou, which allows members of the public to monitor MPs' records and conduct—how often they turn up to the Commons, what questions they ask, and which way they vote on different issues—are impressive examples of sousveillance directly enabled by digital architecture.

While it is not clear that the public would welcome 'energy surveillance' by government or local authorities, smart metering will allow utility companies to collect detailed information anyway. Whether people will perceive this as 'official' surveillance or not is unclear at present, but there is some experimental evidence that users do reduce consumption just because they are aware their habits are being observed. Midden et al (1983) found that a control group reduced their electricity use by 5.6% and gas use by 11.6% while part of his study, presumably simply in response to knowing they were being monitored. As Lutzenhiser (1993) puts it, "such changes in response to 'official observation' are congruent with findings that the provision of feedback on an 'official' monthly letter and/or commendation certificates can improve the effectiveness of information" (Hayes & Cone 1977; Seaver & Patterson 1976).

Looking beyond surveillance, Schneier (2006, p.11) makes the point that security in general "is about *preventing adverse consequences from the intentional and unwarranted actions of others.* What this definition basically means is that we want people to behave in a certain way... and security is a way of ensuring that they do so." In security terminology, *countermeasures*—such as locks, IDs, CCTV, defensive walls, and so on—are "the individual, discrete and independent security components... A security system consists of a series of countermeasures" (Schneier, 2006, p.13). All users are treated as potential 'threats'; systems are designed so that unwanted behaviour is difficult, impossible or at least detectable.[3]

Authentication is an important aspect of security, and often characterised (e.g. Bradley, n.d.) as being about 'what you know' (e.g. a password), 'what you have' (e.g. an access card) or 'who you are' (e.g. biometrics). In the light of the the ideas around 'disciplinary architecture' discussed in Lockton (2011a), it is possible to conceive of a similar, extended categorisation being applied to 'access to functions' in general, to enable or block certain behaviours based on characteristics of the user and his or her prior behaviour. A 'what you've already done' approach might result in an adaptive system giving users

[3]There is a need for countermeasures not to inconvenience 'legitimate' users unduly, for a multitude of reasons, particularly where their cooperation is needed for the system to work. A large body of work exists on 'usable security' (e.g. Cranor and Garfinkel, 2005). Some persuasive technology research centres on encouraging more secure behaviours through the design of systems, for example Forget et al (2008) developed a system to influence users to choose more secure passwords. Anderson (2001) notes that the effectiveness of this kind of security is often more about microeconomic issues—who pays, who is liable, who is inconvenienced—rather than the effectiveness of the technology itself.

different, tailored choices depending on what they had done previously. Thus a perspective on behaviour arising from a security design context could also be applicable to many other situations.

4 Digital persuasion

> "[A]s computers have migrated from research labs onto desktops and into everyday life, they have become more persuasive by design. Today computers are taking on a variety of roles as persuaders, including roles of influence that traditionally were filled by teachers, coaches, clergy, therapists, doctors and salespeople, among others."
>
> B.J. Fogg, *Persuasive Technology: Using Computers to Change What We Think and Do*, Morgan Kaufman, 2003, p.1

Turning away from the 'control' possibilities inherent in digital architecture, the field of *Persuasive Technology* concentrates on experiences more beneficial from the user's perspective: using computers to help people change their own behaviour in ways they want to (see Lockton, 2012c for a discussion of some of the ethical questions involved).

Persuasive Technology, approaching behaviour change from a primarily HCI background, arguably represents the closest 'established' academic field to 'design for behaviour change' in terms of work seeking to use design and technology to influence behaviour for social benefit. B.J. Fogg's 2003 book *Persuasive Technology: Using Computers to Change What We Think and Do* (Fogg, 2003), together with the work of his team at the Persuasive Technology Lab at Stanford, has inspired a series of international conferences and diverse groups of researchers from around the world to develop their work under this banner.

4.1 Fogg's seven persuasive technology tools

Fogg's work builds on Reeves and Nass's (1996) concept of *computers as social actors*—the idea that people instinctively respond to computers (and media more generally) *as if they are other people*, attributing personalities, motivations and attitudes to inanimate devices, even if the interfaces are not specifically designed to be anthropomorphic. Via a doctoral thesis on 'Charismatic Computers', and work on the credibility of different websites, Fogg came to focus on the aspects of interaction with technology intended to change people's attitudes[4], behaviours, or both, coining the term *captology* to describe 'computers as persusasive technologies'. In Fogg's (2003) analysis, computer systems offer a number of advantages over more 'traditional' persuaders: unlike broadcast or print media, computers afford interactivity: they "can adjust what they do based on user inputs, needs and situations" (p.6). Unlike human persuaders, computers also have the ability to be relentlessly persistent, potentially offer users anonymity, deal with large volumes of data and scale easily, "use many modalities to influence", and "go where humans cannot go or may not be welcome" (p.7).

Fogg (2003, p.32-53) defines seven persuasive technology 'tools', each of which "applies a different strategy to change attitudes or behaviours" (p.33). Table 1 summarises these; as explained by Fogg, they are already in forms which are directly applicable by designers, and indeed a number of the tools parallel those discussed in other sections of this review (Lockton 2011a,b; 2012a-f). Fogg notes that multiple tools are often employed in conjunction with one another as part of a product or system. One of the

[4]While Fogg (2003) discusses changing both attitudes and behaviours, most recent work in the Persuasive Technology field seems to have concentrated on behaviours.

Table 1: Fogg's (2003) seven persuasive technology tools.

TOOL	DESCRIPTION & DESIGN IMPLICATIONS
Reduction	Simplifying a procedure: reducing the number of steps needed to complete a task, in order to encourage people to do it. As well as increasing likelihood that a task will be performed correctly, also potentially increases people's belief in their own abilities, leading to a more positive attitude towards the behaviour. See also Maeda's (2006) and Colborne's (2010) treatments of intentional simplicity in interaction design.
Tunnelling	Tunnelling refers to "leading users through a predetermined sequence of actions or events, step by step" (Fogg, 2003, p.34). This is often initiated by people who want to change their own behaviour, e.g. hiring a personal trainer to direct them through a programme. There are parallels with commitment and consistency biases (Cialdini, 2007); in design terms, the most obvious implications are the use of 'wizards' to lead users through a process, and making use of opportunities to deliver messages to audiences who are already 'captive' in some way.
Tailoring	Computers are able to tailor and segment the messages, interfaces and options available to users at different times, in different circumstances, and for different people, making it more likely that the messages delivered will be perceived as personally relevant. Often combined with tunnelling as part of wizard-type systems to offer users directly relevant information and options.
Suggestion	The key to offering suggestions, in Fogg's treatment, is finding the opportune moment—*kairos*—to do so. "Suggestion technologies often build on people's existing motivations... The suggestion technology simply serves to cue a relevant behaviour, essentially saying 'Now would be a good time to do X"' (Fogg, 2003, p.41). In design terms, achieving *kairos* requires an understanding of the situations that users are in, perhaps with monitoring of behaviour or other variables which help determine when (and where, and how) would be a good opportunity to offer a suggestion.
Self-monitoring	This is essentially about giving users the opportunity and capability to receive feedback on their own behaviour, and how it is affecting progress towards a goal. Fogg emphasises using technology to "eliminate the tedium of tracking", making it easy for people to keep track of aspects of behaviour which would otherwise require substantial efforts to monitor. In recent years, the 'quantified self' movement (e.g. Wolf, 2009) has made increasing use of sensors and data analysis to enable self-monitoring, and there are numerous design opportunities in this field.
Surveillance	See section 3.2 of this paper
[Operant] Conditioning	See Lockton (2011b)

most interesting concepts is that of *kairos*, suggestions (or indeed feedback) offered at exactly the right moment to sway a user's behaviour.[5]

While much work on Persuasive Technology centres on *messaging*, drawing on work in communication theory (e.g. Cugelman et al, 2009), Eckles (2007, p.143-4) suggests that particularly with the widespread adoption of mobile phones and other devices, persuasion can occur through "*persuasive faculties*—new senses and reasoning abilities that are designed to change attitudes and behaviours... *these technologies can persuade by becoming part of how people interact with the world.*" As well as enabling new 'senses', Eckles highlights the potential for technology to enable better reasoning abilities, such as allowing someone to simulate the results of different courses of action in a way which would be impossible without processing power. It is conceivable that this approach—more effective simulation and feedforward capabilities (see Lockton 2012a)—could, in due course, alter the bounds of our 'bounded rationality' (see Lockton 2012d), making it possible to 'run' different behaviours virtually beforehand, near-instantaneously.

4.2 The PSD model

Oinas-Kukkonen and Harjumaa (2008) and Räisänen et al (2010) have extended Fogg's seven tools into the 'Persuasive Systems Design' (PSD) model, incorporating both nuanced subdivisions of Fogg's tools and other related behaviour change work such as Cialdini's 'weapons of influence' (see Lockton 2012d)

[5] Along these lines, Slee (2006, p.98) cites a suggestion in Murray (2000) that "the most profitable words in the English language are uttered by McDonald's clerks, who ask, 'Would you like French fries with that?'". The customer must be aware that he or she could already have ordered the fries, yet the suggestion at just the right moment prompts sales which otherwise would not have occurred.

to give 28 principles for developing 'behaviour change support systems'. They reject both conditioning and surveillance as acceptable techniques, from an ethical perspective. The principles are categorised according to the kind of support with which they are intended to provide users: primary task support, dialogue support (between the computer and the user), system credibility support, and social support.

While there is not the scope here to review the entire PSD model, some principles which stand out as potentially interesting for designers (and which have not been covered elsewhere within this review) are the idea of *rehearsal* ("providing means with which to rehearse a behaviour can enable people to change their attitudes or behaviour in the real world"; Oinas-Kukkonen and Harjumaa, 2008, p.170) and *co-operation* ("A system can motivate users to adopt a target attitude or behaviour by leveraging human beings' natural drive to co-operate"; p.173).

4.3 Fogg's Behaviour Grid and Model

At the doctoral consortium preceding the Persuasive 2008 conference, Fogg presented his 'Behaviour Grid', later formalised as Fogg (2009a). This is essentially a matrix of 35 different types of behaviour change with the *schedule* on which they need to occur. For example, a change in behaviour such as 'adopting a dog' is (for most people) a new, unfamiliar behaviour, and also likely to be a one-time behaviour that leads to an ongoing obligation or cost. Deciding to 'eat smaller portions for dinner' is a decrease in the quantity of a behaviour, which needs to occur on a predictable, periodic schedule. The idea is that any intended behaviour change can be classified according to one (or more) of the positions in the matrix.

As part of understanding the possibilities of design for sustainable behaviour, the author attempted to produce a quick application of Fogg's Behaviour Grid to environmentally related behaviours (Table 2). Not all were specifically product-related behaviours, many being related to general lifestyle changes. Fogg subsequently included this table by the author, with permission, in his presentation at the 2009 Design for Persuasion conference in Brussels.

Fogg and Hreha (2010) have since simplified the Behaviour Grid's 35 combinations into 15 target behaviours (a separate use of the term from that used in Lockton, Harrison and Stanton 2010a), each a combination of Dot (one-time), Span (specific duration) and Path (permanent change) durations with green, blue, purple, grey or black flavours, characterising whether a behaviour is familiar or not, and about increasing, decreasing or stopping. For example, in a table of "eco-friendly" example target behaviours, Fogg and Hreha (2010) give "Turn off space heater for tonight" as a 'BlackDot' behaviour—being about stopping doing something just once. In contrast, "Don't water lawn during summer" would be a 'BlackSpan' behaviour, and "Never litter again" would be a 'BlackPath'.

The revised Behaviour Grid offers a relatively simple and potentially useful way to structure thinking around behaviour change, particularly in the form of its natural extension into the Behaviour Wizard (Stanford Behaviour Wizard Team, 2011), a website and accompanying series of resource guides which help the user decide which target behaviour is most applicable to the situation at hand, and then suggest some relevant issues to consider, with examples. While not quite the 'BehaviourTRIZ' imagined in some early versions of the author's Design with Intent toolkit, as the Stanford Behaviour Wizard is developed, it will present a highly structured way of prescribing solutions for behaviour problems, compared with the currently relatively free-form Design with Intent toolkit (Lockton, Harrison and Stanton, 2010b). It is not inconceivable that they could be combined in some form in the future.

The Fogg Behaviour Model (2009b) also deserves mention. Simply, the model "asserts that for a person to perform a target behaviour, he or she must (1) be sufficiently motivated, (2) have the ability to perform the behaviour, and (3) be triggered to perform the behaviour. These three factors must occur at the same moment, else the behavior will not happen." As a simplification of many of the behavioural

Table 2: An application of Fogg's Behaviour Grid to environmentally related behaviours by the author

		A	B	C	D	E
	Type of behaviour / **Schedule**	**Perform *new* behaviour (unfamiliar)**	**Perform *existing* behaviour (familiar)**	**Increase behaviour (frequency, intensity, duration)**	**Decrease behaviour (frequency, intensity, duration)**	**Stop behaviour (cease ongoing behaviour)**
1	**One-time behaviour**	Have a home energy audit	Share a taxi	Spend more money for something that lasts longer	Buy fewer physical gifts this Christmas	Refuse a plastic lid for your coffee this once
2	**One-time behaviour that leads to ongoing obligation or cost**	Learn how to repair clothes	Wash & take your own mug to the coffee shop or machine	Invest in a teleconferencing system	Pledge to buy fewer new clothes	Don't replace the tumble dryer when it breaks
3	**Behaviour for a period of time / duration**	Try shopping with a list for a month	Take the train this holiday	Open the windows more instead of using air conditioning this summer	Go a month using the car less	Don't fly anywhere this year
4	**Behaviour on cue (cued irregularly, change in habitual response)**	Cycle to work every day	Pull the curtains every evening	Buy more locally produced food every time you go shopping	Shower for less time each morning	Don't leave the tap running while brushing your teeth
5	**Behaviour on a predictable schedule (repeated, periodically)**	Sort rubbish into recyclables	Ask for tap water in restaurants	Unplug chargers more often when not in use	Reduce paper use by printing double-sided	Decline a plastic carrier bag when you're at the supermarket checkout
6	**Behaviour is at will (can perform at any moment)**	Work out your carbon footprint	Put jumper on when cold, rather than turning up heating	Walk more often	Eat less meat when offered it	Stop putting the TV on standby
7	**Behaviour is always performed (change in habit, way of being)**	Consider everything you do in terms of your environmental impact	Always turn lights off when leaving the room	Pay more to get your electricity from a renewable source	Don't overfill the kettle	Decide not to try to start a family

models discussed in this review, Fogg's model links both personal and contextual factors. More recently, Fogg has used the mantra "Put 'hot' triggers in the path of motivated people" in a number of conference presentations, where 'hot' triggers are those which coincide with someone having the ability to take action (as opposed to cold triggers). In a sustainable behaviour context, if (for example) a person is motivated to recycle a piece of litter, and something (a message, a sign, a text alert) triggers him or her to recycle it, the behaviour will nevertheless only occur if the ability (a recycling bin being present) exists. There are parallels with Lewin's *channel factors*, "apparently minor but actually important details" in the context of situations which have the effect of being "critical facilitators or barriers" (Ross and Nisbett, 1991, p.10).

5 A brief note on games

Over the duration of the author's research, *gamification* (Deterding et al, 2011) has arisen as a significant phenomenon in digital media: using elements from game design in (traditionally) non-game contexts, particularly on social networking services, to engage users and influence behaviour. The elements or game mechanics adopted include the idea of 'levels' and scores, 'badges' for achievement, escalating challenges matched to skill levels (drawing on Csíkszentmihályi's *Flow* (1990)), and unpredictable reinforcement (see also Lockton, 2011a). The thinking is that since games (physical and digital) are able to engage and motivate players for long periods of time, giving them feelings of challenge, achievement and satisfaction, some of the elements which make games successful in these situations could be adapted for use elsewhere.[6]

Alternatively, other tasks or behaviours could be effectively 'turned into games' themselves, making an interaction 'playful' or adding variety so that each time it is performed, there is something new or exciting to experience. McGonigal (2011) suggests that compared to the satisfying, often exhilarating world of games, "reality is broken"; she offers examples such as Kevan Davis's *Chore Wars*, a game "to help you track how much housework people are doing—and to inspire everyone to do more housework, more cheerfully, than they would otherwise" (p.120) as possible 'fixes' for the 'broken' elements of everyday life which mean that we do not always behave as we would like to. McGonigal's paean to the potential of games for improving the human condition suggests that education, democracy, social cohesion, work-life balance and organisational performance can all be transformed: effectively, large-scale behaviour change mediated by games.

Despite the current vogue for gamification of often superficial behaviours, as an extension of companies' advertising campaigns—e.g. Bogost (2011) describes it as "invented by consultants as a means to capture the wild, coveted beast that is videogames and to domesticate it for use in the grey, hopeless wasteland of big business"—there is a parallel, more academically established field of *serious games* (e.g. Zyda, 2005), which seek to use games as an educational or training tool, and indeed *persuasive games* (Bogost, 2007).

Bogost (2007) concentrates on the existence of *procedural rhetoric* in games, as compared with classical verbal rhetoric and visual rhetoric. Procedual rhetoric is "the practice of using processes persuasively... the practice of authoring arguments through processes... arguments made not through the construction of words or images, but through the authorship of rules of behaviour" (p. 28-29). In Bogost's treatment, procedural rhetoric means that playing games can be essentially about uncovering 'how things work': the rules of behaviour, the affordances and constraints designed into games by their authors are what create the game for the player, and authors can use these to influence players' attitudes and behaviours, both inside and outside the games, for political, educational or simply advertising ends.[7]

[6] Design patterns based on some game elements were belatedly included in Design with Intent v.1.0 in the 'Ludic' lens (Lockton, Harrison and Stanton 2010b).

[7] Bogost himself specialises in creating 'videogames with an agenda', such as *Cow Clicker* (Bogost, 2010), "a Facebook

Implications for designers

- The affordances and constraints designed into digital systems necessarily influence or have the potential to influence user behaviour
- While the law is a substantial regulator of behaviour offline, online it is 'code' (i.e. software, and the hardware architecture of the Internet) that structures what people can and cannot do
- 'Tethered appliances' and DRM permit restriction and control of users' behaviour in ways which go beyond what is easily done offline, for example enforcing business models and enabling more complete surveillance
- Perspectives on behaviour arising from a security design context could also be applicable to many other situations
- The Internet can be seen as a generative system, which does not itself seek to influence behaviour, but it does enable services to be built on top of it which in turn enable lots of new behaviours—such as souveillance by the public—as well as changing the ease with which certain behaviours can be influenced
- There are parallels between physical architecture and digital architecture and their influence on behaviour, but also new and different affordances emerging from ubiquitous computing and similar fields
- Persuasive Technology brings together context and cognition, the environment and the person, including consideration of personal aspects such as motivation alongside environmental aspects such as 'triggers'
- People may respond to computers (and media more generally) as if they are other people, attributing personalities, motivations and attitudes to inanimate devices, even if the interfaces are not specifically designed to be anthropomorphic; this effect could be used to influence behaviour in a variety of ways
- Computer systems offer some advantages in terms of persuasion, affording interactivity, tailored responses, persistence, anonymity, multiple modes of operation and adaptability to different contexts
- Fogg's 'seven tools'—reduction, tunnelling, tailoring, suggestion, self-monitoring, surveillance and operant conditioning can all easily be adapted for use in design contexts
- Increasing computational power and widespread adoption of mobile devices could lead to new 'persuasive faculties'—technology could enable better reasoning abilities, such as allowing someone to simulate or 'rehearse' the results of different courses of action
- The Fogg Behaviour Model—comprising motivation, ability, and trigger—is a simple way of analysing situations to assesss which elements need to be addressed to influence behaviour. Design can deal with all three elements, though often concentrating on triggers
- Games work at intersection of the 'context' and 'cognition' blades of 'Simon's scissors' (see Lockton 2012e)—effectively *creating artificial contexts* structured to lead to certain cognitive processes

game about Facebook games" which satirises the more pointless elements of many popular 'social games' while operating in almost exactly the same way as the games it mocks.

- The rules, affordances and constraints designed into games can influence players' attitudes and behaviours, both inside and outside the games
- Game elements and mechanics can be used to influence behaviour in (traditionally) non-game contexts, particularly on social networking services, to engage users and influence behaviour, e.g. levels and scores, 'badges' for achievement, escalating challenges matched to skill levels and unpredictable reinforcement
- Alternatively, tasks or behaviours could be effectively 'turned into games' themselves, making an interaction 'playful', more engaging or adding variety so that each time it is performed, there is something new or exciting to experience

References

Anderson, R. (2001). 'Why Information Security is Hard: An Economic Perspective'. In: *Proceedings of 17th Annual Computer Security Applications Conference, ACSAC 2001.*

Bateson, M, Nettle, D & Robert, G (2006). 'Cues of being watched enhance cooperation in a real-world setting'. *Biology Letters* 2(3), 412–414.

BBC News (2011). 'Egypt protesters use voice tweets'. BBC News, 1/2/2011. Available at http://www.bbc.co.uk/news/technology-12332850 [Accessed 10 September 2011]

Bleecker, J (2006) 'Why Things Matter: A Manifesto for Networked Objects—Cohabiting with Pigeons, Arphids and Aibos in the Internet of Things'. Near Future Laboratory, 26/2/2006. Available from http://www.nearfuturelaboratory.com/files/WhyThingsMatter.pdf [Accessed 10 September 2011]

Bogost, I (2007). *Persuasive Games: The Expressive Power of Videogames.* MIT Press, Cambridge, MA.

Bogost, I (2010). 'Cow Clicker: The Making of Obsession'. 21/7/2010. Available at http://www.bogost.com/blog/cow_clicker_1.shtml [Accessed 10 September 2011]

Bogost, I (2011). 'Gamification is Bullshit: My position statement at the Wharton Gamification Symposium'. 8/8/2011. Available at http://www.bogost.com/ blog/gamification_is_bullshit.shtml [Accessed 10 September 2011]

Bradley, T. (not dated) 'What is Two-Factor Authentication? Understanding what two-factor authentication is and how it works'. About.com. Available at http://netsecurity.about.com/ od/quicktips/qt/twofactor.htm [Accessed 10 September 2011]

Brand, S (2009). *Whole Earth Discipline: An Eco-Pragmatist Manifesto.* Viking, New York, NY.

Brin, D. (1998). *The Transparent Society.* Addison-Wesley, Reading, MA.

Cialdini, R.B. (2007). *Influence: the Psychology of Persuasion (Revised Edition).* Collins, London [originally published 1984]

Colborne. G. (2010). *Simple and Usable: Web, Mobile and Interaction Design.* New Riders, Berkeley, CA

Conti, G (2009). *Googling Security: How Much Does Google Know About You?* Addison-Wesley, Upper Saddle River, NJ

Cranor, L F & Garfinkel, S (eds) (2005). *Security and Usability: Designing Secure Systems That People Can Use.* O'Reilly, Sebastopol, CA.

Csíkszentmihályi, M. (1991). *Flow: the Psychology of Optimal Experience.* Harper Perennial, New York, NY

Cugelman, B, Thelwall, M & Dawes, P (2009) 'Communication-Based Influence Components Model'. *Proceedings of Persuasive Technology: Fourth International Conference, Persuasive 2009*, Claremont, CA

Deterding, S., Dixon, D., Nacke, L. E., O'Hara, K., and Sicart, M. (2011) 'Gamification: Using Game Design Elements in Non-Gaming Contexts'. In: *Proceedings of CHI 2011, Extended Abstracts*, Vancouver, BC

Doctorow, C (2004). 'Microsoft Research DRM talk'. 17/6/2004. Available at http://dashes.com/ anil/stuff/doctorow-drm-ms.html [Accessed 10 September 2011]

Eckles, D (2007) 'Redefining Persuasion for a Mobile World'. In: Fogg, B. J. & Eckles, D. (eds.), M*obile Persuasion: 20 Perspectives on the Future of Behaviour Change*. Stanford Captology Media, Palo Alto, CA.

Fleishman, G (2009) 'Double Plus Ungoods: Amazon Unpublishes Orwell'. TidBITS, 19/7/2009. Available at http://db.tidbits.com/ article/10417 [Accessed 10 September 2011]

Fogg, B J (2003) *Persuasive Technology: Using Computers to Change What We Think and Do*. Morgan Kaufmann, San Francisco, CA.

Fogg, B J (2009a) 'The Behavior Grid: 35 ways behavior can change'. *Proceedings of Persuasive Technology: Fourth International Conference, Persuasive 2009*, Claremont, California

Fogg, B J (2009b) 'A behavior model for persuasive design'. *Proceedings of Persuasive Technology: Fourth International Conference, Persuasive 2009*, Claremont, California

Fogg, B J & Hreha, J (2010) 'Behavior Wizard: A Method for Matching Target Behaviors with Solutions'. *Proceedings of Persuasive Technology: Fifth International Conference, Persuasive 2010*, Copenhagen

Forder, J (2000). 'Permission to hyperlink?' *CCH Law and Technology*, 19, Mar 2000

Forget, A, Chiasson, S, van Oorschot, P C & Biddle, R (2008). 'Persuasion for Stronger Passwords: Motivation and Pilot Study'. *Proceedings of Persuasive Technology: Third International Conference, Persuasive 2008*, Oulu, Finland, June 4-6, 2008, Springer, 140–150.

Freeman, D & Freeman, J (2008). *Paranoia: The 21st-Century Fear*. Oxford University Press, Oxford.

Gillespie, T (2007). *Wired Shut: Copyright and the Shape of Digital Culture*. MIT Press, Cambridge, MA

Gillett, S.E., Lehr, W.H., Wrocklawski, J.T. & Clark, D.D. (2001) 'Do Appliances Threaten Internet Innovation?,' *IEEE Communications*, October 2001

Greenfield, A. (2006). *Everyware: The Dawning Age of Ubiquitous Computing*. New Riders, Berkeley, CA.

Greenfield, A. (2011) 'Weeks 18-20: Walking and unweaving the urban mesh, Bristol/London'. Urbanscale blog, 19/5/2011. Available at http://urbanscale.org/ 2011/05/19/weeks-18-20-walking-and-unweaving-the-urban-mesh-bristollondon/ [Accessed 19 May 2011]

Grossman, L (2009) 'Iran Protests: Twitter, the Medium of the Movement'. *Time*, 17/6/2009. Available at http://www.time.com/ time/world/article/0,8599,1905125,00.html [Accessed 10 September 2011]

Hayes, SC & Cone, JD, (1977). 'Reducing residential electrical energy use: Payments, information and feedback', *Journal of Applied Behavior Analysis* 10, 425-435

Hill, B M (2007) 'Anti-Features'. Free Software Foundation blog. Available at http://www.fsf.org/ blogs/community/antifeatures [Accessed 10 September 2011]

Kanuparthy, P & Dovrolis, C (2011). 'End-to-end Detection of ISP Traffic Shaping using Active and Passive Methods'. Georgia Tech. Available at http://www.cc.gatech.edu/ grads/p/partha/shaperprobe-TR.pdf [Accessed 10 September 2011]

Kaptein, M. & Eckles, D (2010) 'Selecting Effective Means to Any End: Futures and Ethics of Persuasion Profiling'. *Proceedings of Persuasive Technology: Fifth International Conference, Persuasive 2010*, Copenhagen, Denmark

Katyal, N.K. (2003). 'Digital Architecture As Crime Control'. *Yale Law Journal* 112, 2261

Lessig, L. (1999). *Code and Other Laws of Cyberspace.* Basic Books, New York, NY

Lockton, D. (2005) *Architectures of Control in Consumer Product Design.* Master's dissertation, Judge Institute of Management, University of Cambridge. Available at http://papers.ssrn.com/ sol3/papers.cfm?abstract_id=908493 [Accessed 1 September 2010]

Lockton, D. (2011a). 'Architecture, urbanism, design and behaviour: a brief review'. Design with Intent blog, 12 September 2011. Available at http://architectures.danlockton.co.uk/ 2011/09/12/architecture-urbanism-design- and-behaviour-a-brief-review/ [accessed 5 August 2012]

Lockton, D. (2011b). 'Design and behaviourism: a brief review'. Design with Intent blog, 19 July 2011. Available at http://architectures.danlockton.co.uk/ 2011/07/19/design-and-behaviourism-a-brief-review/ [accessed 5 August 2012]

Lockton, D. (2012a). 'Affordances, constraints and information flows as 'leverage points' in design for sustainable behaviour'. Working paper, April 2012, available at http://papers.ssrn.com/sol3/ papers.cfm?abstract_id=2120901 [accessed 6 August 2012]

Lockton, D. (2012b). 'Attitudes, meaning, emotion and motivation in design for behaviour change'. Working paper, August 2012, available at http://papers.ssrn.com/sol3/ papers.cfm?abstract_id=2123495 [accessed 6 August 2012]

Lockton, D. (2012c). 'POSIWID and determinism in design for behaviour change'. Working paper, April 2012, available at http://papers.ssrn.com/sol3/ papers.cfm?abstract_id=2033231 [accessed 6 August 2012]

Lockton, D. (2012d). 'Cognitive biases, heuristics and decision-making in design for behaviour change'. Working paper, August 2012, available at http://papers.ssrn.com/sol3/ papers.cfm?abstract_id=2124557 [accessed 6 August 2012]

Lockton, D. (2012e). 'Simon's scissors and ecological psychology in design for behaviour change'. Working paper, August 2012, available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2125405 [accessed 7 August 2012]

Lockton, D. (2012f). 'Social and interpersonal approaches to design for behaviour change'. Working paper, August 2012, available at http://papers.ssrn.com/sol3/ papers.cfm?abstract_id=2124913 [accessed 6 August 2012]

Lockton, D., Harrison, D.J. & Stanton, N.A. (2010a). 'The Design with Intent Method: a design tool for influencing user behaviour'. *Applied Ergonomics* 41(3), 382-392

Lockton, D., Harrison, D.J. & Stanton, N.A. (2010b). *Design with Intent: 101 Patterns for Influencing Behaviour Through Design v.1.0*, Equifine, Windsor, UK.

Losh, E M (2009). *Virtualpolitik: An Electronic History of Government Media-Making in a Time of War, Scandal, Disaster, Miscommunication, and Mistakes.* MIT Press, Cambridge, MA.

Lutzenhiser, L., (1993). 'Social and Behavioral Aspects of Energy Use'. *Annual Review of Energy and Environment* 18, 247 — 89

Maeda, J (2006). *The Laws of Simplicity: Design, Technology, Business, Life.* MIT Press, Cambridge, MA.

McAfee, R.P. (2002) *Competitive Solutions: The Strategist's Toolkit.* Princeton University Press, Princeton, NJ

McAfee, R.P. (2007) 'Pricing Damaged Goods'. *Economics Discussion Papers*, 2007-2, Kiel Institute for the World Economy. Available at http://www.economics-ejournal.org/ economics/discussionpapers/2007-2 [accessed 10 September 2011]

McCullough, M (2004). *Digital Ground: Architecture, Pervasive Computing, and Environmental Knowing.* MIT Press, Cambridge, MA

McGonigal, J (2011) *Reality is Broken: Why Games Make Us Better and How They Can Change the World.* Jonathan Cape, London

Midden, CJH, Meter, JE, Weenig, MH & Zieverink, HJA (1983). 'Using feedback, reinforcement and information to reduce energy consumption in households: A field experiment', *Journal of Economic Psychology* 3, 65–86

Murray. A (2000). *The Weatlth of Choices: How the New Economy Puts Power in Your Hands and Money in Your Pocket.* Crown, New York, NY

Negroponte, N (1995). *Being Digital.* Coronet.

Odlyzko, A (2004) 'The Evolution of Price Discrimination in Transportation and its Implications for the Internet.' *Review of Network Economics* 3(3), 323–346

Oinas-Kukkonen, H. and Harjumaa, M. (2008) 'A Systematic Framework for Designing and Evaluating Persuasive Systems'. *Proceedings of Persuasive Technology: Third International Conference, Persuasive 2008*, Oulu, Finland, June 4-6, 2008, Springer, 164–176.

Pariser, E (2011). *The Filter Bubble: What the Internet is Hiding From You.* Viking, London

Raisanen, T, Lehto, T & Oinas-Kukkonen, H (2010) 'Practical findigns from applying the PSD model for evaluating software design specifications'. In: *Proceedings of Persuasive Technology: Fifth International Conference, Persuasive 2010, Copenhagen, Denmark, June 7-9, 2010*

Ramasastry, A (2005) 'Web sites change prices based on customers' habits'. CNN.com, 24/6/2005. Available at http://articles.cnn.com/ 2005-06-24/justice/ramasastry.website.prices_1_price-differentials-price-discrimination-customers?_s=PM:LAW [Accessed 10 September 2011]

Reeves, B & Nass, C (1996). *The Media Equation: How People Treat Computers, Television and New Media Like Real People and Places.* CSLI Publications, Palo Alto, CA / Cambridge University Press, Cambridge, UK

Ross, L., & Nisbett, R. E. (1991). *The Person and the Situation: perspectives of social psychology.* McGraw-Hill, New York, NY

Saltzer, J H, Reed, D P & Clark, D D (1984) 'End-to-end arguments in system design'. *ACM Transactions in Computer Systems* 2(4), 277-288

Schneier, B. (2006). *Beyond Fear: Thinking Sensibly About Security in an Uncertain World.* Copernicus Books, New York, NY.

Seaver, WB & Patterson, AH, 1976. 'Decreasing fuel-oil consumption through feedback and social commendation', *Journal of Applied Behavior Analysis* 9, 147-152

Shapiro, A L (1999). *The Control Revolution: how the Internet is putting individuals in charge and changing the world we know.* PublicAffairs, New York, NY

Slee, T (2006). *No-One Makes You Shop At Wal-Mart: The Surprising Deceptions of Individual Choice.* Between The Lines, Toronto

Spinellis, D & Louridas, P (2008). 'The collaborative organization of knowledge'. *Communications of the ACM* 51(8), 68–73

Stanford Behavior Wizard Team (2011) 'The Behavior Wizard: Easy Access to Powerful Strategies'. Available at http://behaviorwizard.org [Accessed 10 September 2011]

Sterling, B (2005). *Shaping Things.* MIT Press, Cambridge, MA

Tredinnick, L. (2009). 'Complexity theory and the web', *Journal of Documentation*, 65(5), 797–816

Vaidhyanathan, S (2005). *The Anarchist in the Library: How the Clash Between Freedom and Control is Hacking the Real World and Crashing the System.* Basic Books, New York, NY

Wolf, G (1995). 'The Curse of Xanadu'. *Wired*, 3.06

Wolf, G (2009). 'Know Thyself: Tracking Every Facet of Life, from Sleep to Mood to Pain, 24/7/365'. *Wired*, 17.07

Zittrain, J (2008). *The Future of the Internet And How to Stop It.* Allen Lane, London.

Zyda, M (2005). 'From Visual Simulation to Virtual Reality to Games'. *IEEE Computer*, 8(9), 25–32